INDOOR AIR QUALITY ASSESSMENT

District Court of Worcester County
(Worcester District Court)
50 Harvard Street
Worcester, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
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Background/Introduction

In response to a request from Joseph Indrisano, Regional Court Facilities Manager, the Massachusetts Department of Public Health's (MDPH) Center for Environmental Health (CEH) conducted an indoor air quality assessment at the District Court of Worcester [Worcester District Court (WDC)], 50 Harvard Street Worcester, Massachusetts. Concerns about indoor air quality, mold and water damage in the Worcester County District Attorney's Office (DA's Office) prompted the request.

On November 24, 2004, Michael Feeney, Director of CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program, made an initial visit to this building. Mr. Feeney returned on March 25, 2005 to complete the evaluation of the building. The WDC is a four-story, grey brick, steel frame building constructed in 1965. The building is connected to the rear of the original Worcester Court House, which is not the subject of this report. Windows are openable in a number of areas in the building.

Prior to MDPH's assessment, an environmental consultant, Boston Environmental & Engineering Associates, Inc. (BEEAI) also conducted their own investigation. Based on their findings, BEEAI made the following recommendations for remediation in the DA's Office suite: clean and sanitize the heating, ventilating and air-conditioning (HVAC), vacuum flat surfaces with a vacuum equipped with a high efficiency particle arrestance (HEPA) filter and install exhaust fans in restrooms (BEEAI, 2004).

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, model 8551.

Results

The courthouse has an employee population of approximately 140, and several hundred visitors to the WDC on a daily basis. Tests were taken under normal operating conditions and results appear in Tables 1 and 2. Air sampling results are listed in the tables by location that the air sample was taken.

Discussion

Ventilation

It can be seen from Tables 1 and 2 that carbon dioxide levels were above 800 parts per million parts (ppm) in twenty-two of thirty-eight areas sampled on November 24, 2004 and two out of nine areas sampled on March 25, 2005. It did not appear that the ventilation system was activated during either days of assessment. These results indicate inadequate fresh air supply in a number of areas, particularly those with large populations (e.g., courtrooms). Please note that carbon dioxide levels below 800 ppm were measured in unoccupied areas or with low population.

Ventilation is provided by various air-handling units (AHUs) with fresh air intakes located on the roof (Picture 1) and at ground level (Picture 2) of the building. MDPH staff received numerous complaints concerning heat control in this building. The lack of heat control appears to be related to the design of the ventilation systems. Fresh air is distributed through the building by diffusers (Picture 3) that, in the experience of MPDH staff, are used in buildings with a large indoor space requiring heat (e.g., department stores or industrial settings). Courtrooms at the WDC are outfitted with four of these air diffusers per ceiling (Picture 4). Some offices converted from use as jury rooms have two of these vents.

Of significant importance is the location of the return vent at the *center* of the fresh air diffuser (Picture 3). In most buildings examined by MDPH staff, fresh air supplies and exhaust vents are generally located on opposite sides of a room in an effort to create airflow. The design of these fresh air supply/exhaust vents would likely limit the amount of exhaust air drawn into each return vent. The aperture of the exhaust vent appears to be at least six times less than that of each fresh air supply vent, thereby decreasing the volume of air that can be removed as compared to that supplied. Moreover, the draw of air to the exhaust vent is interrupted by the presence of the supply vents and the location of furniture. In this configuration, heat and normally occurring indoor environmental pollutants would tend to linger in rooms, rather than be readily removed from the building.

To maximize air exchange, the MDPH recommends that all components of the ventilation system (e.g., supply ventilation, exhaust ventilation and FCUs) operate continuously during business hours. Without the HVAC system operating as designed, normally occurring pollutants cannot be diluted or removed, allowing them to build up and leading to indoor air quality/comfort complaints. In order to have proper ventilation, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997). The ventilation must be on at all times that the room

is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time-weighted average (OSHA, 1997).

The MPDH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, see Appendix A.

Temperature readings of 71^{o} to 79^{o} F were within the MDPH recommended range for comfort in most areas (Tables 1 and 2). The MDPH recommends that indoor air temperatures be maintained in a range between 70^{o} to 78^{o} F in order to provide for the comfort of building occupants. Heat concerns were expressed by those at the jury pool court officer's desk outside the jury poolroom and also by occupants in a converted office space (former jury deliberation room).

The jury pool court officer's desk is located in a hallway outside two jury rooms (Picture 5). The sole source of fresh air and exhaust ventilation in this area is a ceiling mounted fresh air diffuser/exhaust vent unit described previous. A number of pieces of office equipment that produce waste heat (e.g. photocopier, computer monitor) are also located in the area. Due to the design of the ventilation system, exhaust ventilation is limited in this area.

Exhaust ventilation limitations may also be the root of heat concerns in the converted office space (former jury deliberation room). A bathroom adjoins this converted office space. The exhaust ventilation for the restroom is designed to draw air through the bathroom door, thereby providing some exhaust ventilation for this room. However, the exhaust fan for the bathroom is inoperable. Without adequate exhaust ventilation in these areas, waste heat can build up in these areas, resulting in decreased comfort of area occupants.

Another area with heat concerns is an internal office within the DA's Office. In an effort to control temperature during summer months, a portable air conditioner was installed inside this office (Picture 6). This air conditioner is *designed* for use in a building that has a ceiling plenum[1] return air system. Based on the unit design, waste heat generated by the portable air conditioner would be drawn into the ventilation system. However, the HVAC system at the WDC is *ducted* for both supply and return. The WDC *does not* use the ceiling plenum for return ventilation. In this room, heated air is vented into the ceiling, which pressurizes the area above the ceiling to force hot air back into the room. This system should be ducted directly to a vent in the exterior wall.

[1] The space above a suspended ceiling is called a plenum

The relative humidity in the building was within a range of 35 to 48 percent on November 24, 2005, which is within or close to the MDPH recommended range. On March 25, 2005, the relative humidity ranged from 19 to 35 percent, which is below the recommended rage. The MDPH recommends a range of 40-60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. It is important to note, however, that relative humidity measured indoors exceeded outdoor measurements during the second assessment (range +1 to 10 percent). This increase in relative humidity can indicate that the exhaust ventilation is not sufficient to remove normal indoor air pollutants (e.g., water vapor from respiration). Moisture removal is important since the sensation of heat conditions increase as relative humidity increases (the relationship between temperature and relative humidity is called the heat index). As indoor temperature rises, the addition of more relative humidity will make occupants feel hotter than the actual temperature. For example, a temperature of 75^{o} F with relative humidity of 50% would produce a heat index so that an individual would feel the temperature as equivalent to 81^{o} F (USFA/FEMA, 2000). If moisture is removed, the comfort level of the individual increases. Removal of moisture from the air, however, can have some negative effects. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Prior to the MDPH visit, court facilities staff executed a number of remedial efforts to address concerns of the DA's Office. As reported by Mr. Indrisano, a

mechanical room for equipment servicing the DA's Office was found to contain mold from materials stored in this area. Since ducts and the AHU were not sealed, the potential for mold-related contaminants to be drawn into the HVAC system would be a concern. However, (as reported by Mr. Indrisano), all materials stored in this mechanical room were removed and the HVAC system was cleaned. MDPH staff found the mechanical room clean and cleared of moldy materials. Other steps taken by court facilities staff include removal of carpet from the DA's Office and blocking of the fresh air supply in the DA's Office with hard plastic to reduce air venting directly onto the occupied space. As reported by the DA's Office staff, after implementation, these remediation efforts reduced symptoms in many employees.

The WDC has an interlocking ceiling tile system (Picture 7). Several hallways and offices have ceiling tiles that appear to be water-damaged by old roof leaks. Replacement of these ceiling tiles is difficult due to their design. The American Conference of Governmental Industrial Hygienists (ACGIH) and the United States Environmental Protection Agency (US EPA) recommend that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (ACGIH, 1989; US EPA, 2001). If porous materials are not dried within this time frame, mold growth may occur. Water-damaged porous materials cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy porous materials is not recommended. Fungal microbial growth begins once water soaks porous materials.

Plants were observed in a number of rooms. Moistened plant soil and drip pans can provide a source of mold growth. Plants are also a source of pollen. Plants should be located away from the air stream of ventilation sources to prevent the aerosolization of mold, pollen or particulate matter throughout the area. Plants should have drip pans to

prevent wetting and subsequent mold colonization. Over watering of plants should be avoided and drip pans should be inspected periodically for mold growth.

Other Concerns

Indoor air quality can be adversely impacted by the presence of respiratory irritants, such as products of combustion or sewer gas. Occupants reported periodic complaints of vehicle exhaust entrainment from vehicles parked along the courtrooms serviced by the ground level fresh air intakes shown in Picture 2. During certain wind and weather conditions, vehicle exhaust can potentially be drawn, or entrained, through the univent fresh air intakes. This in turn may provide opportunities for exposure to compounds such as carbon monoxide. M.G.L. chapter 90 section 16A prohibits the unnecessary operation of the engine of a motor vehicle for a foreseeable time in excess of five minutes (M.G.L., 1986).

A sewer vent pipe was observed in close proximity to fresh air intakes on the roof. Under certain wind conditions, sewer gas from this vent may be entrained by the HVAC system.

Recommendations

It appears that the remediation steps taken to clean the DA's Office and HVAC system, as well as efforts to remove moldy materials from the mechanical room have reduced symptoms of individuals in this section of the building. In view of the findings at the time of the visit, the following recommendations are made:

1. Seal exhaust vents of fresh air/exhaust units located along exterior walls. In addition, seal supply vents of multi-clustered fresh air/exhaust units located along

hallway interior walls. Sealing these vents would maximize airflow and likely improve control over heat provide by the HVAC system. A ventilation engineer should be consulted concerning this alteration to the HVAC system.

2. Consult a ventilation engineer concerning re-balancing of the ventilation systems. Ventilation industrial standards recommend that mechanical ventilation systems be balanced every five years (SMACNA, 1994).

3. Examine all restroom exhaust vents and repair where necessary. Ensure that adequate transfer air source exist for each restroom vent to function. If no transfer air vent exists in restroom doors, undercut each door to create a minimum of 1 inch.

4. Vent the portable air conditioner in the DA's Office outdoors.

5. Examine the feasibility of improving exhaust ventilation for the jury pool area.

6. Consider sealing the fresh air supply for the jury pool court officer's desk. As an interim measure, place the high efficiency particle arrestance (HEPA) filter located behind the desk next to the photocopier and office door to intercept pollutants. Consider moving the photocopier to an area of larger volume that is equipped with exhaust ventilation.

7. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all non-porous surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

8. Consider posting signs instructing vehicles to park face in towards the building and to shut engines off after five minutes as required by Massachusetts General Laws 90:16A.

9. Extend the height of sewer vent pipes on the roof a minimum of 2 feet above fresh air intakes for AHUs.

References

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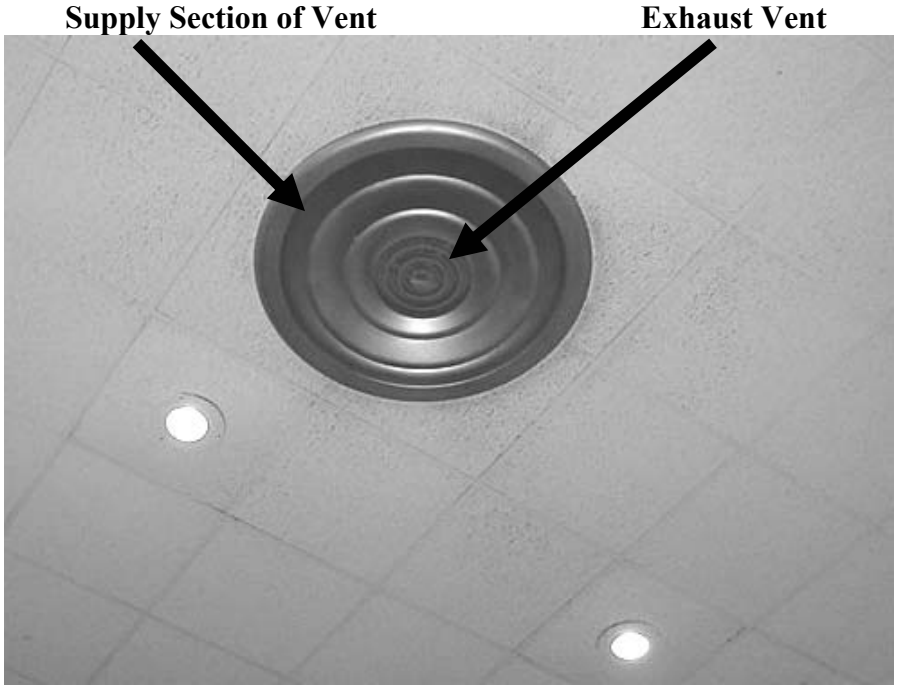
Picture 1

Rooftop Fresh Air Intake Vents (Note Sewer Vent Pipe on Foreground)

Picture 2

Ground Level Fresh Air Intake Vents (Note Position of Car with Tail Pipe Pointed Towards Intake)

Picture 3



Fresh Air Diffuser and Exhaust Vent

Picture 4

Court Room Ceiling with Air Diffusers (One of Four in Room)

Picture 5

Jury Pool Court Officer Desk

Picture 6

Portable Air Condition in DA's Office, Note Flexible Hose into Ceiling (Composite)

Picture 7

Interlocking Ceiling Tiles

TABLE 1

Indoor Air Test Results

District Court of Worcester County (Worcester District Court)
50 Harvard Street
Worcester, MA
November 24, 2004

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Outside (Background)	391	46	61					
Front lobby, security area	963	72	42	20+	N	Y	Y	
408	1747	71	43	60+	Y	Y	Y	Broken window
407	1726	71	44	30+	Y	Y	Y	20+ Water damaged ceiling tiles
401	1600	72	42	30+	Y	Y	Y	
403	1364	72	40	1	N	Y	Y	Supply and exhaust vents off 1 missing ceiling tile
Judge's Lobby	1295	72	39	6	Y	Y	Y	Plants Photocopier
404	871	70	37	0	Y	Y	Y	Water damaged plaster Matierals on radiator
417	1344	72	48	20=	Y	Y	Y	

*** ppm = parts per million parts of air**

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

Table 1-1

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November 24, 2004

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						Supply	Exhaust	
417 Assistant Clerk's Office	1219	73	42	3	Y	Y	Y	Window open
417 private office	1430	73	42	3	Y	Y	Y	Door open
416	1085	73	37	3	Y	Y	Y	2 missing ceiling tiles
415	1072	73	39	20+	Y	Y	Y	Door open
415 private office	1365	72	39	1	Y	Y	Y	Door open
Jury pool court officer desk	1377	73	43	2	N	Y	Y	Supply and exhaust off
Juror A	1600	73	43	20+	Y	Y	Y	Door open
3rd floor Team Room	689	73	36	0	N	N	N	Door open
Juror B	1036	72	39	0	Y	Y	Y	Door open

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						Supply	Exhaust	
305	1309	73	40	5	Y	Y	Y	
305 vault	883	73	40	1	N	N	N	Used as employee breakroom room Food odors Door open
305-4	823	73	36	1	Y	Y	Y	1 missing ceiling tile Door open
305-1	918	71	36	0	Y	Y	Y	2 missing ceiling tiles 5 water damaged ceiling tiles
305-2	1000	72	37	1	Y	Y	Y	Plants Door open
305-3	952	72	38	0	Y	Y	Y	Door open
202	1117	78	38	3	N	Y	Y	Humidifier Rest exhaust vent off
DA's foyer	566	73	30	2	Y	Y	Y	Plants

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						Supply	Exhaust	
DA'a assistant	530	73	41	1	Y	Y	Y	Plants
DA's reception	576	71	40	2	Y	Y	Y	Plants
DA-1	597	71	41	0	Y	Y	Y	Door open
DA-2	458	70	41	0	Y	Y	Y	Door open
DA Library	518	71	41	0	Y	Y	Y	Exhaust vent closed
DA Fiscal	660	73	43	1	Y	Y	Y	Door open Portable air conditioner vented above suspended ceiling
DA 215	575	73	39	0	Y	Y	Y	Door open
DA 213	591	73	39	0	Y	Y	Y	Door open

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						Supply	Exhaust	
DA 212	499	72	39	0	Y	Y	Y	Door open
DA 210	539	73	38	1	Y	Y	Y	
DA 209	513	72	35	0	Y	Y	Y	
DA 209 Judge's Lobby	470	72	35	0	Y	Y	Y	
DA Computer Annex	642	73	36	0	Y	Y	Y	

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TABLE 2

Indoor Air Test Results

District Court of Worcester County (Worcester District Court)
50 Harvard Street
Worcester, MA
March 25, 2005

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Outside (Background)	371	53	21					
Bisceglia Office	406	72	25	0	Y	N	N	
Housing Court Clearks	457	73	24	3	Y	Y	Y	3 missing ceiling tiles
Housing Court Administration Office	551	77	26	2	Y	Y	Y	
Housing Court Conference Room	458	79	22	0	Y	Y	Y	
House Court Session	421	76	19	0	Y	Y	Y	
Probate Court #1	1028	71	35	50+	Y	Y	Y	Plants
Probate Court #2	756	74	27	6	Y	Y	Y	Plants 10 water damaged ceiling tiles

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District Court of Worcester County (Worcester District Court)
50 Harvard Street
Worcester, MA
March 25, 2005

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Cafeteria	1020	75	27	30+	Y	Y	Y	
Basement hallway	765	74	26	4	N	N	N	

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